JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1980, 34, 107-116 NUMBER 1 (JULY)

EFFECTS OF d-AMPHETAMINE AND PENTOBARBITAL UNDER CONCURRENT FIXED-RATIO SCHEDULES

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Pigeons were studied under a two-key concurrent fixed-ratio schedule of food presentation. During the first five sessions, the fixed-ratio requirements were 30 responses on one key (major key) and 120 responses on the other key (minor key): responding occurred almost exclusively on the major key. When the fixed-ratio requirements were then made equal at 30 responses on both keys, responding continued to predominate on the major key. The asymmetric distribution of responses persisted when the concurrent fixed-ratio fixed-ratio schedule was interrupted with periods during which the major key was associated with extinction while the other key remained associated with a fixed-ratio schedule. Additionally, in some subjects the fixed-ratio requirements were increased. These schedule modifications decreased the asymmetry in responding but did not eliminate it. *d*-Amphetamine decreased rates on both keys and slightly increased the asymmetric distribution of responses, while pentobarbital reversed the distribution of responses by increasing low rates and decreasing high rates. The pigeons maintained their original asymmetric distribution of responses during the 1½-year-long study, despite schedule alterations and drug administrations.

Key words: concurrent schedule, *d*-amphetamine, pentobarbital, FR schedule of reinforcement, suppression, alternative reinforcement, key peck, pigeon

Many investigators have been interested in how subjects distribute their responses between keys under concurrent schedules. One frequent finding is that under some conditions the proportion of responses made on a key matched the proportion of reinforcements associated with that key (de Villiers, 1977; Herrnstein, 1970). Deviations from this matching relationship do occur. In analyzing these deviations Baum (1974) referred to response bias in which a subject prefers a key out of proportion to the reinforcements associated with that key because of characteristics such as ease of movement or being on the left or the right. For example, Baum and Rachlin (1969) studied the time spent on the left or right side of a chamber in relation to the reinforcements obtained on either side. The results did not fall on a matching curve because the proportion of time spent on one side was greater than the proportion of reinforcements associated with that side. Baum (1974) postulated that factors other than color or position could also affect bias.

Some studies have dealt with the prediction or manipulation of response bias in two-key situations. Herrnstein (1958) suggested that preference in the pigeon did not appear related to any property of the key or to prior experience of the subjects. Glick (1973) proposed that side preferences in the rat may be due to an inherent dominance in the brain of one nigrostriatal pathway over the contralateral side. Since preference is often viewed as an inherent and predetermined quality, little attention has been given to the possible influence of a subject's history on preference in concurrent schedules. While the characteristics of performance under concurrent schedules depend critically upon the prevailing contingencies, it is important to consider that these performances may be influenced by the subject's early training when it is initially exposed to the schedule. Differences in early training may have long-term effects on subsequent behavior and perhaps on preference. For example, Terrace (1963) found that the number of errors in discrimination was related to the

Research supported by USPHS Grants MH02094 and MH07658. I thank W. H. Morse, P. B. Dews, R. T. Kelleher, G. R. Wenger, J. Katz, R. D. Spealman, and J. DeWeese for helping prepare the manuscript and C. J. Mosher for illustrating. Reprints may be obtained from the author, Laboratory of Psychobiology, Harvard Medical School, 25 Shattuck Street, Boston, Massachusetts 02115.

nature of initial training. Performance on two keys of a concurrent schedule may similarly be influenced by early training.

In the present study an early training period of only five sessions established responding predominantly on one key under a two-key concurrent schedule. During these five sessions one key was associated with a fixed-ratio 30 schedule (FR 30) while the other was associated with a fixed-ratio 120 schedule (FR 120). Responding occurred predominantly on the key associated with the FR 30 schedule by the end of the five sessions. Thus, an asymmetry of responding was established which persisted even after the fixed-ratio requirements associated with each key were made equal. The key pecked predominantly will be called the major key while the key pecked infrequently will be called the minor key.

Interventions were made which decreased the prepotent responding on the major key and, in some cases, increased responding on the minor key. The concurrent fixed-ratio fixed-ratio (conc FR FR) schedule was altered by periodically introducing a period, signaled by a discriminative stimulus, during which the schedule on the major key became extinction (EXT), while the FR schedule on the minor key was unchanged. With the addition of these periods, and by changing the FR requirements for the two keys, different degrees of minor-key responding were obtained. The effects of drugs were also studied. Increasing doses of *d*-amphetamine slightly increased the proportion of responses occurring on the major key while pentobarbital decreased this proportion or actually reversed the distribution of responses.

METHOD

Subjects

Eight adult male White Carneaux pigeons were maintained at about 75% of their unrestricted-feeding weights (about 450 to 500 grams) and had unlimited access to water in their home cages. Pigeons 135, 137, and 140 had no previous training, while Pigeons 107, 108, 110, 112, and 1669 had been studied under various schedules of reinforcement with a single-response key.

Apparatus

The apparatus was similar to the one described by Ferster and Skinner (1957). Two keys (R. Gerbrands Co.) were mounted 11 cm apart and 25 cm above the mesh floor on the front panel and could be transilluminated by a white light. A peck with a force greater than .15 N on either key was recorded as a response and produced a click of a feedback relay. The minimal force, .15 N, required to produce a click was equal for the two keys. The feeder opening, which allowed access to mixed grain, was centered 10 cm below the keys and was illuminated by white lamps when operated. The chamber could be illuminated by a 25-W white bulb (houselight) located parallel to the back wall near the ceiling and operated through a series resistance of 300 ohms. White noise was present at all times.

Procedure

Pigeons not previously studied were trained to peck on a single key. Each pigeon was then exposed for five sessions to a concurrent fixed-ratio 30 fixed-ratio 120 schedule (conc FR 30 FR 120) of food presentation. Both keys were transilluminated with white lights and the houselight was off. Completion of the FR requirement on one key always reset the FR requirements on both keys. Food presentation lasted 3 sec during which the feeder was lighted and the keylights were off. Each of the first five sessions lasted from 75 to 100 reinforcements depending on the pigeon's presession weight, thereafter, all sessions ended after 75 food presentations or after 1 hr had elapsed. The FR 30 schedule was associated with the left key for Pigeons 107, 110, 135, and 137 and with the right key for Pigeons 108, 112, 140, and 1669. Responding eventually occurred almost exclusively on the key initially associated with the FR 30 schedule. This key will be termed the major key for each pigeon. The other key, initially associated with the FR 120 schedule, will be termed the minor key. The schedule associated with the major key will be written first and that associated with the minor key second, so that conc EXT FR 30 signifies the major key associated with an extinction schedule and the minor key associated with an FR 30 schedule.

After the initial five sessions described above, the pigeons were divided into three groups. Group I consisted of Pigeons 107, 108, 110, and 112; Group II consisted of Pigeons 137 and 1669; Group III consisted of Pigeons 135 and 140. In each group the number of

pigeons with the major key on the right versus on the left were equal. Slightly different procedures were in effect for the three groups, but the following details remained constant between groups. After the first five sessions the schedule was changed from a conc FR 30 FR 120 schedule to a multiple schedule in which 5-min periods under a conc FR FR schedule, with the houselight off, alternated with 1-min periods with the houselight illuminated. During these periods with the houselight on, the major key was associated with an extinction schedule and the minor key was associated with an FR schedule. Thus, the total schedule may be considered a multiple schedule with a conc FR FR component (houselight off) and a conc EXT FR component (houselight on). Responses were counted separately for the two keys and the two components of the multiple schedule. Responses and reinforcers associated with each key were recorded continuously and separately with two cumulative recorders.

The sequence of schedules for each group are given in Table 1. For the pigeons in Group I, a 5-min conc FR 30 FR 60 component alternated with a 1-min conc EXT FR 60 component. For Group I this schedule was maintained throughout the remainder of the study. For the pigeons in Group II and Group III, a 5-min conc FR 30 FR 30 component alternated with a 1-min conc EXT FR 30 component. For one or two sessions, the duration of the conc EXT FR 30 component was temporarily increased to 2 min which caused minor-key responding to increase during this component. This increased responding persisted even after the schedule components returned to the 5-min conc FR 30 FR 30 component alternating with 1 min of a conc EXT FR 30 component. Several sessions were conducted under this schedule to observe whether performances would revert to their original pattern. For Group II the components were then changed to a 5-min conc FR 30 FR 60 component alternating with a 1-min conc EXT FR 60 houselight component. For Group III the components were changed to a 5-min conc FR 60 FR 60 component alternating with a 1-min conc EXT FR 60 component.

Drugs were administered only after 15 consecutive sessions of stable performances as determined by comparison of daily cumulative records. Drugs and saline were given no more often than twice in a week, each administration being immediately preceded by a control day. Solutions of *d*-amphetamine sulfate and sodium pentobarbital were prepared so that all injections were of 1.0 ml/kg. Drugs were measured in milligrams of the salt. Injections were made into the breast muscle 5 min before the start of the session. Results presented are based on two to four replications of each dose level per subject. Dose-response curves for *d*-amphetamine were determined first; then those for pentobarbital were determined.

Table 1

Sequence of schedules and range of sessions prior to drug studies for each group of subjects. Five-min components with the houselight off alternated with 1-min components with the houselight on. During each component two keys, major and minor, were associated with separate schedules of reinforcement. Drug studies were carried out under the schedules listed last for each group.

	Schedule				
	Houselight off (5 min)		*Houselight on (1 min)*		
Subjects	*Major key*	*Minor key*	*Major key*	*Minor key*	*Range of sessions*
Group I	FR 30	FR 120	–	–	5
	FR 30	FR 60	EXT	FR 60	53-91
Group II	FR 30	FR 120	–	–	5
	FR 30	FR 30	EXT[a]	FR 30	49-126
	FR 30	FR 60	EXT	FR 60	15-16
Group III	FR 30	FR 120	–	–	5
	FR 30	FR 30	EXT[a]	FR 30	75-80
	FR 60	FR 60	EXT	FR 60	21-55

[a]This component was lengthened to 2 min for Session 20 for Pigeon 137, Sessions 8 and 9 for Pigeon 1669, Sessions 14 and 15 for Pigeon 135, and Sessions 38 and 39 for Pigeon 140.

RESULTS

Control Responding

Average rates of responding on each key for the five sessions immediately before the start of drug experiments are summarized in Figure 1. The pattern of major key responding was similar in all subjects. During the conc FR FR component, mean rates of responding on the major key were high, approximately 2 responses per sec. During the conc EXT FR component (houselight on) the mean rates on the major key were low, .05 response per sec or less. The pattern of minor-key responding differed between each of the groups of subjects. In Group I the mean rates of responding on the minor key were initially low, approximately .02 response per sec in both compo-

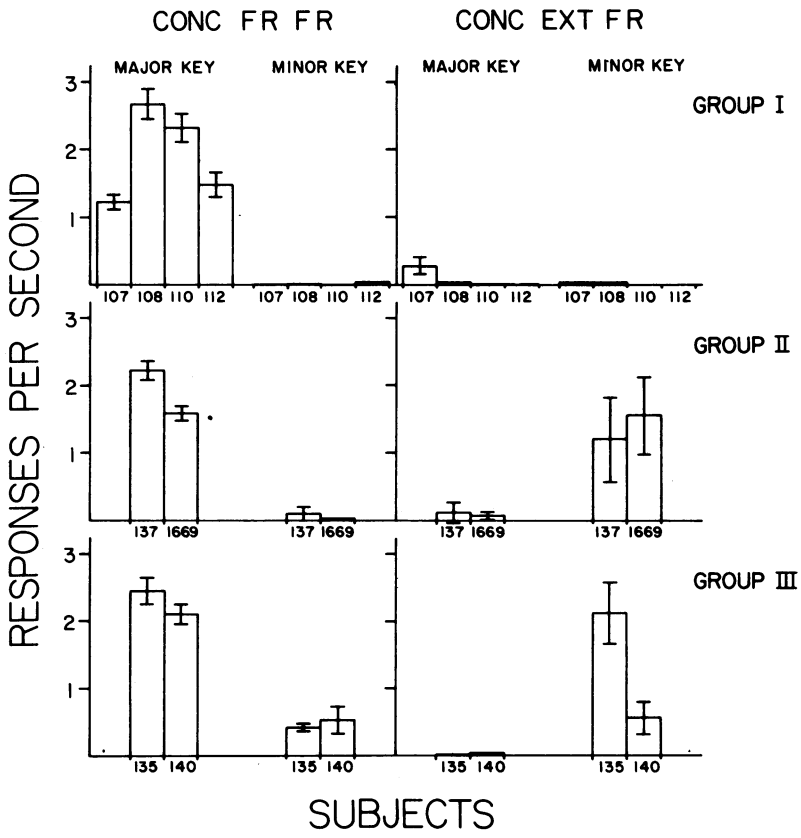

Fig. 1. Major- and minor-key response rates in responses per second before starting drug experiments. Responding of each subject is shown separately for the two keys under the conc FR FR component (left) and the conc EXT FR component (right). Each bar represents the mean ±S.D. of five control sessions.

nents; and they remained low throughout the study. In Groups II and III, the mean rates of responding on the minor key were initially low; the temporary prolongation of the conc EXT FR component, from 1 min to 2 min induced minor-key responding in both groups which persisted throughout the study. In Group II the mean rates of responding on the minor key averaged .05 response per sec during the conc FR 30 FR 60 component and 1.25 responses per sec or higher during the conc EXT FR 60 component. In Group III the mean rates of responding on the minor key averaged .45 response per sec during the conc FR 60 FR 60 component and 1.34 responses per sec during the conc EXT FR 60 component.

Typical cumulative records of control performances are shown in Figure 2 (left-hand column). In sum, major-key responding predominated with the exception of intermittent breaks in responding during the conc EXT FR components in which major key responding was under extinction. There were three different patterns of minor-key responding for the three groups of subjects: little minor-key responding at all times (Group I); minor-key responding only during the conc EXT FR component (Group II); and minor-key responding during the conc EXT FR component and immediately after this component during the conc FR FR component (Group III).

Effects of d-*Amphetamine*

Mean control rates for each subject during drug studies and rates after *d*-amphetamine and pentobarbital administration are shown in Table 2. *d*-Amphetamine had no effect or decreased responding on both keys. In Group I neither the high rate of responding on the major key during the conc FR 30 FR 60 component nor the low rate of responding on the major key during the conc EXT FR 60 houselight component was increased; similarly the

Table 2
Average rate of responding for each pigeon under control conditions plus and minus one standard deviation and after administration of saline, *d*-amphetamine, and pentobarbital.

		d-Amphetamine				*Pentobarbital*				
		conc FR FR		*conc EXT FR*			*conc FR FR*		*conc EXT FR*	
Pigeon	*Dose*	*Major key*	*Minor key*	*Major key*	*Minor key*	*Dose*	*Major key*	*Minor key*	*Major key*	*Minor key*
107	C	1.36±.18	.02±.04	.21±.13	.08±.03	C	1.51±.18	.02±.01	.24±.28	.02±.03
Group I	NaCl	1.24	.01	.15	.01	NaCl	1.51	.00	.15	.03
	.3	1.18	.00	.10	.00	3.0	1.77	.01	.06	.29
	1.0	.56	.00	.00	.00	10	2.04	.07	1.18	.37
	3.0	.00	.00	.00	.00	13	1.67	.01	1.16	.28
	5.6	.00	.00	.00	.00	18	.00	.00	.00	.00
108	C	2.29±.41	.01±.01	.02±.02	.02±.02	C	1.91±.40	.00±.00	.02±.01	.02±.01
Group I	NaCl	1.60	.01	.02	.02	NaCl	1.94	.00	.01	.01
	.3	2.30	.03	.01	.04	3.0	2.53	.00	.04	.02
	1.0	2.19	.00	.01	.01	10	2.23	.17	.02	.32
	3.0	.46	.00	.01	.04	13	2.48	.12	.16	.35
	5.6	.00	.00	.00	.00	18	1.38	.05	.05	.20
110	C	2.31±.17	.01±.01	.01±.01	.00±.00	C	2.27±.16	.01±.00	.02±.01	.01±.00
Group I	NaCl	2.32	.02	.01	.01	NaCl	2.26	.01	.00	.01
	.3	2.02	.01	.01	.00	3.0	2.74	.01	.01	.00
	1.0	1.59	.01	.01	.00	10	2.57	.05	.02	.01
	3.0	.19	.00	.00	.00	13	2.14	.01	.03	.02
	5.6	.00	.00	.00	.00	18	1.09	.02	.03	.04
112	C	1.68±.35	.02±.05	.02±.04	.01±.00	C	1.81±.27	.01±.02	.02±.01	.01±.00
Group I	NaCl	1.59	.00	.01	.00	NaCl	1.72	.00	.01	.00
	.3	1.12	.00	.01	.00	3.0	2.11	.00	.04	.00
	1.0	.17	.07	.00	.00	10	2.49	.03	.04	.00
	3.0	.00	.00	.00	.00	13	1.46	.08	.05	.00
	5.6	.00	.00	.00	.00	18	.63	.03	.03	.00
137	C	2.15±.15	.07±.08	.04±.09	1.05±.69	C	2.38±.12	.01±.02	.01±.01	1.39±.49
Group II	NaCl	2.24	.04	.01	1.26	NaCl	2.36	.02	.02	1.34
	.3	2.14	.03	.02	1.40	3.0	2.72	.00	.00	1.59
	1.0	1.78	.02	.02	.30	10	2.63	.10	.14	2.22
	3.0	1.26	.03	.00	.00	13	2.51	.08	.42	2.17
	5.6	.00	.00	.00	.00	18	1.50	.09	.62	.37
1669	C	1.64±.16	.04±.06	.10±.19	1.26±.65	C	1.62±.15	.03±.06	.03±.04	.91±.64
Group II	NaCl	1.52	.01	.02	.62	NaCl	1.69	.02	.07	.78
	.3	1.10	.06	.02	1.61	3.0	1.85	.06	.13	.25
	1.0	1.65	.03	.06	.28	10	2.03	.11	.57	.01
	3.0	1.27	.07	.03	.11	13	2.08	.02	.88	.09
	5.6	.74	.03	.05	.03	18	.00	.00	.00	.00
135	C	2.33±.40	.38±.23	.02±.02	2.52±.56	C	2.48±.38	.22±.22	.03±.08	2.34±.44
Group III	NaCl	2.05	.54	.02	2.59	NaCl	2.42	.26	.04	2.72
	.1	2.22	.33	.01	1.87	1.0	2.22	.34	.01	2.50
	.3	2.08	.27	.01	1.63	3.0	2.27	.55	.01	2.67
	1.0	1.80	.49	.01	1.42	10	.55	1.96	.05	2.56
	3.0	1.64	.00	.01	.00	13	.47	1.55	.14	1.96
						18	.03	.70	.00	.80
140	C	1.92±.29	.54±.22	.08±.10	.63±.35	C	1.23±.41	.33±.39	.02±.03	.39±.41
Group III	NaCl	1.85	.49	.11	.89	NaCl	1.24	.14	.02	.15
	.1	1.76	.78	.03	.61	1.0	1.12	1.00	.01	.77
	.3	1.15	.80	.03	.07	3.0	.83	1.91	.01	2.06
	1.0	1.99	.16	.01	.09	10	1.04	1.38	.23	1.74
	3.0	1.28	.02	.00	.00	13	.70	1.27	.07	.98
						18	.00	.00	.00	.00

minor-key rates of responding were not increased in either component (Figure 2, top panel, and Figure 3). In Group II the major-key rates of responding were not increased during either component. The minor-key rates of responding were also not increased and

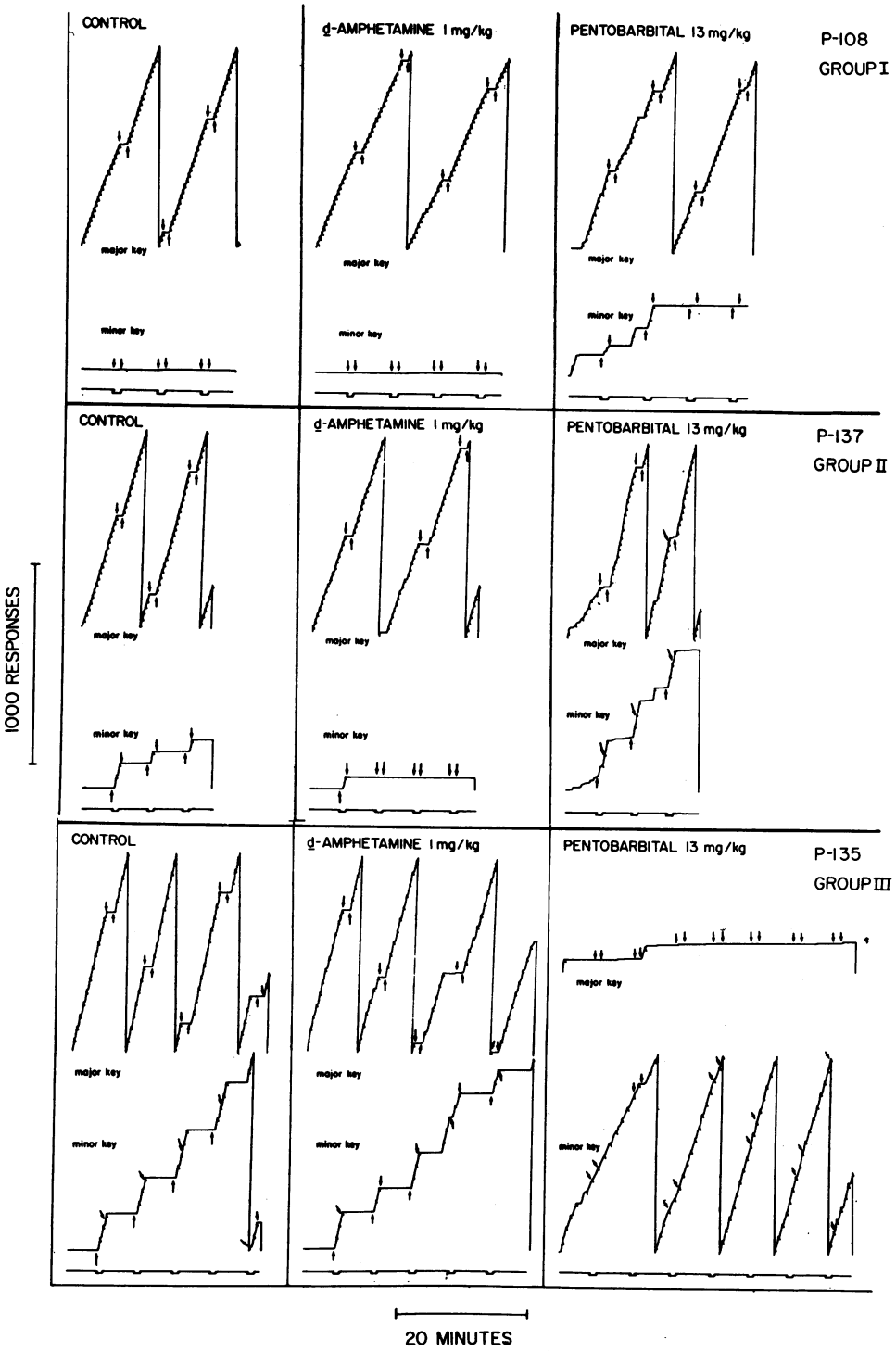

Fig. 2. Representative performances of Pigeons 108 (Group I), 137 (Group II), and 135 (Group III) on major and minor keys under control conditions, after 1 mg/kg *d*-amphetamine and after 13 mg/kg pentobarbital. Abscissae: time; ordinates: cumulative number of key-peck responses. Records of concurrent responding on the two keys are aligned vertically. Arrows indicate change of component. On the horizontal line beneath the records an upward displacement indicates conc FR FR while a downward displacement indicates conc EXT FR. Short diagonal strokes on the cumulative record represent food presentations. Each record represents a complete session.

the substantial minor-key rate of responding during the conc EXT FR 60 component fell quickly with increasing doses. The fall occurred at doses below those decreasing major-key responding during the conc FR 30 FR 60 component (Figure 2, middle panel, and Figure 3). Similarly, in Group III the major-key rates of responding were not increased during either component. Minor key rates of responding, which were substantial during both components, were decreased progressively with increasing dose and at doses below those decreasing major-key responding (Figure 2, bottom panel, and Figure 4).

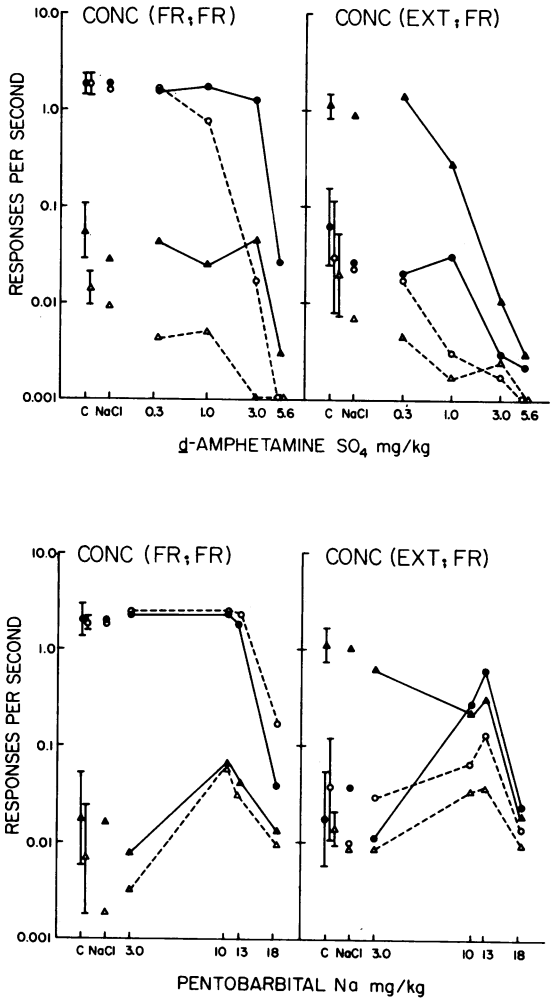

Fig. 3. Effect of *d*-amphetamine sulfate and sodium pentobarbital on the average rates of responding on the major key (circles) and minor key (triangles) during conc FR 30 FR 60 and conc EXT FR 60. Abscissae: dose in milligrams of salt per kilogram of body weight on a log scale; ordinates: log responses per second. Dashed lines and unfilled symbols connect points representing the mean of the logged average rates for Pigeons 107, 108, 110 and 112, Group I. Solid lines and filled symbols connect similarly calculated points for Pigeons 137 and 1669, Group II. Points and vertical lines at C represent the mean of the pigeons' logged average control rates ±2 Standard Errors which were calculated with n equaling the number of pigeons.

Effects of Pentobarbital

The effects of pentobarbital on the rates of responding were consistently related to the control rates of responding. Low control rates of responding were increased and high control rates of responding were decreased or un-

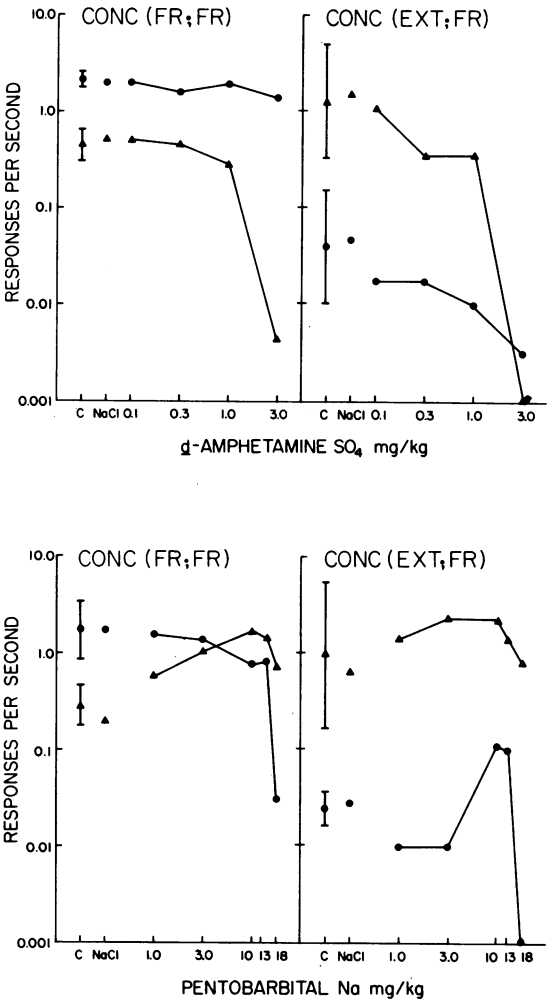

Fig. 4. Effects of *d*-amphetamine sulfate and sodium pentobarbital on the concurrent average rates of responding on the major (circles) and minor (triangles) keys during conc FR 60 FR 60 and conc EXT FR 60. Abscissae, ordinates, and vertical lines at C are described in Figure 3. Solid lines connect points representing the mean of the logged average rates for Pigeons 135 and 140, Group III.

changed, without regard to whether the responding occurred on the major or minor key. In Group I the high rates of responding on the major key during the conc FR 30 FR 60 component were not affected at doses that increased the low rate of responding on the major key during the conc EXT FR 60 component. Minor-key rates of responding, which were low during both components, were increased by pentobarbital (Figure 2, top panel, and Figure 3). In Group II pentobarbital similarly decreased the high major-key rates of responding and increased the low major-key rates of responding. The low minor-key rates of responding during the conc FR 30 FR 60 were increased while the high minor-key rates during the conc EXT FR 60 component were decreased (Figure 2, middle panel, and Figure 3). In Group III during the conc FR 60 FR 60 component, pentobarbital decreased the high major-key rate of responding concomitant with an increase of the relatively lower minor-key rate of responding. The effect was so dramatic that the dose-effects curves during the conc FR 60 FR 60 component crossed as minor-key responding became greater than major-key responding. During the conc EXT FR 60 houselight component, there was no increase in the already high rate of minor-key responding but the low rate of major-key responding was increased (Figure 2, bottom panel, and Figure 4). In all three Groups, despite large repeated reversals of the pattern of responding caused by pentobarbital, the control performance was reliably reproduced subsequent to each drug intervention. Moreover, there was surprisingly low variability in the control performance throughout the year and a half duration of the study.

DISCUSSION

Control Responding

Five sessions with the major key programmed under an FR 30 schedule and the minor key programmed under an FR 120 schedule sufficed to establish which key a subject predominantly pecked for the subsequent year and a half. Once the difference in FR requirements between keys had established an asymmetric distribution of responses, the asymmetry persisted even when the difference in FR requirements was reduced or removed. This persistence may reflect the positive feedback feature of FR schedules. Continued responding on one key increases the frequency of reinforcement on that key and further maintains the tendency to respond on that key.

The introduction of 1-min periods of the conc EXT FR component, occurring every 5 min, served to interrupt periodically and decrease the previously established major-key responding but did not induce minor-key responding. Brief prolongation of the conc EXT FR component, however, resulted in an increase in, and reinforcement of, minor-key responding, which was sustained even when the component was returned to a 1-min duration. Another schedule alteration, increasing the FR requirements from 30 to 60 (Group III), further increased minor-key responding. Now, with the larger FR requirements, the 1-min conc EXT FR component frequently ended in the middle of an FR run. The run of responding on the minor key would then be completed and reinforcement would be obtained during the conc FR 60 FR 60 component. Such reinforcement induced and maintained the minor-key rate of responding of about .37 response per sec during conc FR 60 FR 60 components. Even though the majority of responding still occurred on the major key, the asymmetric distribution of responses could be substantially decreased by the described schedule modifications.

Drug Effects

Previous investigations have studied the effects of drugs on the distribution of responses between concurrent schedules. Segal (1962) found no effect of *d*-amphetamine on response distribution. She studied the effects of *d*-amphetamine on a concurrent variable-interval differential-reinforcement-of-low-rates (conc VI DRL) schedule of reinforcement. The rates associated with each schedule were increased proportionately and thus the distribution of responses between keys was not appreciably altered. Indeed, even the number of VI responses between two consecutive DRL responses was not significantly changed. In contrast, Todorov, Gorayeb, Correa, and Graeff (1972) found that *d*-amphetamine increased the asymmetry in the distribution of responses under a concurrent variable-interval variable-interval (conc VI VI) schedule of reinforcement. The control performance consisted of a high rate of responding on one key, the "main key," which was reinforced according to

a schedule determined by responses on a changeover key (cf. Findley, 1958). Responding on the changeover key occurred at a low rate and produced a time out which was less than 1 sec. Both the rates on the "main key" and the rates on the changeover key were decreased by *d*-amphetamine. Changeover-key responding was decreased at doses below those decreasing "main key" responding, thus causing an increase in the proportion of responses on the "main key" with increasing *d*-amphetamine doses. These results are similar to those of the present study in which minor-key responding decreased at lower doses of *d*-amphetamine than major-key responding. The contrasting results of Segal and Todorov et al. suggest that amphetamine may not affect the distribution of responses the same way in all situations. In the study by Segal, both rates of responding associated with the VI and DRL schedules were about equal and *d*-amphetamine did not affect the distribution of responses. In the study by Todorov et al., "main-key" rates of responding were always higher than the changeover-key rates of responding and *d*-amphetamine did influence the distribution of responses. Relating different effects of drugs to different control performances is now an old concept which has been amply documented in single-schedule studies (Dews, 1958; Dews & Wenger, 1977; Kelleher & Morse, 1968). Bacotti (1979) has recently extended this concept to concurrent schedules using both *d*-amphetamine and pentobarbital. Using concurrent schedules he found that manipulation of a schedule parameter would alter the control performance on both keys, which in turn altered the effects of drugs.

A knowledge of the interactions occurring between the schedules of each key during control performances may be essential to understanding the effects of drugs on concurrent performances. Spealman, Katz, and Witkin (1978) studied such interactions between two keys. In their study one key served as a stimulus whose color depended on whether a VI or EXT component of a multiple schedule was associated with a second key. Responding that occurred on this stimulus key was increased by pentobarbital. When the discriminative property of the stimulus key was removed by changing the multiple schedule so that the reinforcement frequencies were equal in each component, pentobarbital did not increase the stimulus-key responding. In contrast, *d*-amphetamine decreased stimulus-key responding in both situations. Catania (1969) studied another type of interaction between keys in which one key serves as an inhibitory stimulus relative to the responding on another key. He suggested that reinforcement for responding on one key inhibits responding on a second key. Such an inhibitory or suppressive interaction may play a role in the present study. Although there were no apparent noxious stimuli in the present study, there may have been suppressive influences on responding. For example, during the conc FR FR component, responses on the major key or the corresponding reinforcements may have suppressed responding on the minor key. If the major key had been removed, responding surely would have increased on the minor key. Responding that has been suppressed to low levels can be increased by pentobarbital but, except after special histories, not by *d*-amphetamine (Dews & DeWeese, 1977). In the present study *d*-amphetamine decreased all rates of responding including the low rates on the minor key, while pentobarbital increased all low rates of responding. The differential effects of *d*-amphetamine and pentobarbital on responding in this study may reflect the effects of these drugs on suppressed responding.

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Received June 6, 1978
Final acceptance December 17, 1979